Frequency of severe storms and global warming

George Aumann

15 April 2008

Submitted to GRL March 2008

Outline

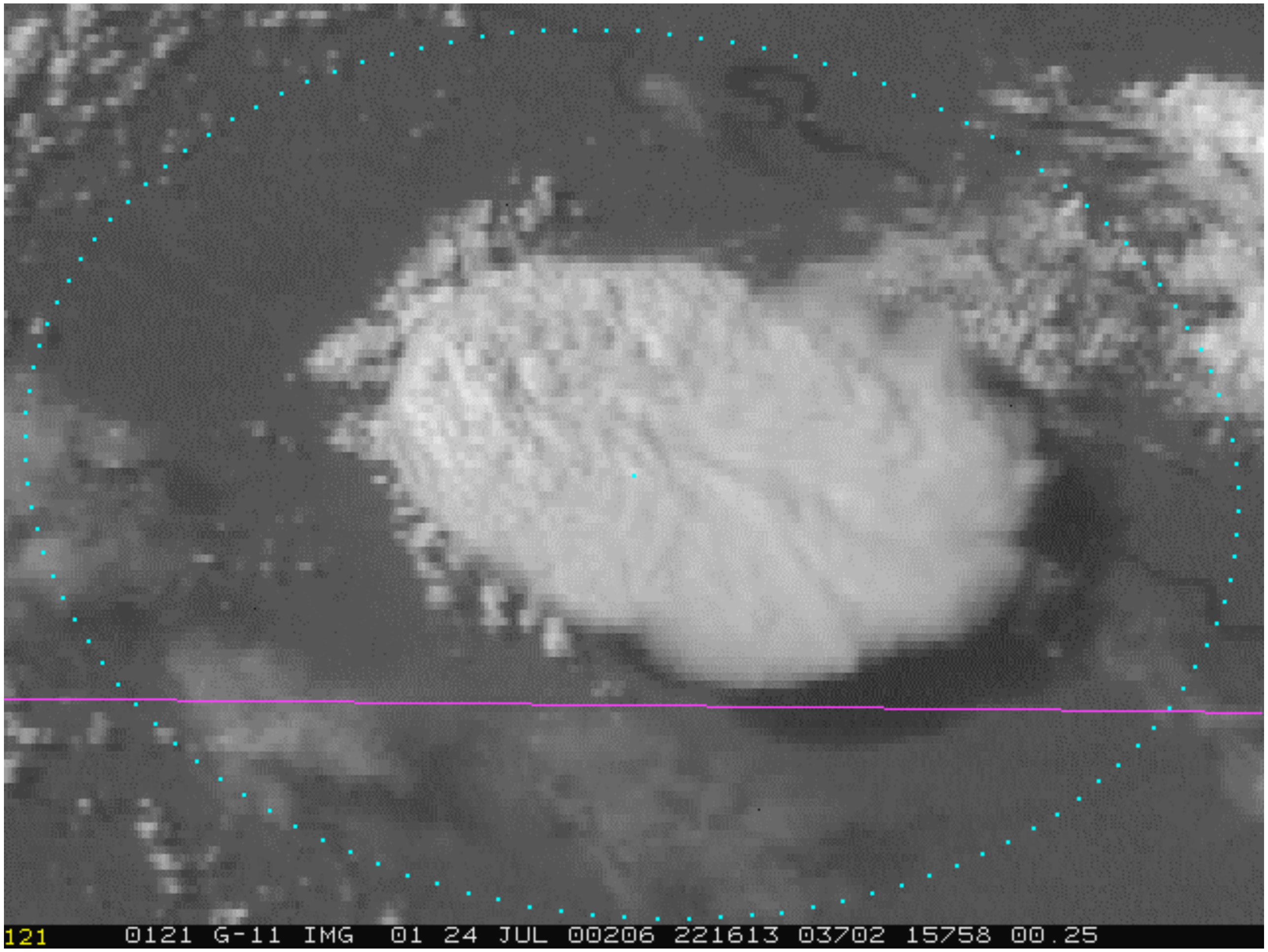
Deep Convective Clouds (DCC)
and severe storms

Do we expect the frequency of DCC to increase
with global warming?

Do we see a DCC frequency trend in the AIRS data?

DCC and stratospheric water

DCC were discovered using GOES data.
Reynolds (1986) and Purdom (1991) correlated
DCC with severe storms and extreme precipitation



The green dots are a 15 km footprint

H. H. Aumann

The association of strong convection with high surface temperatures is well known (Waliser 1993).

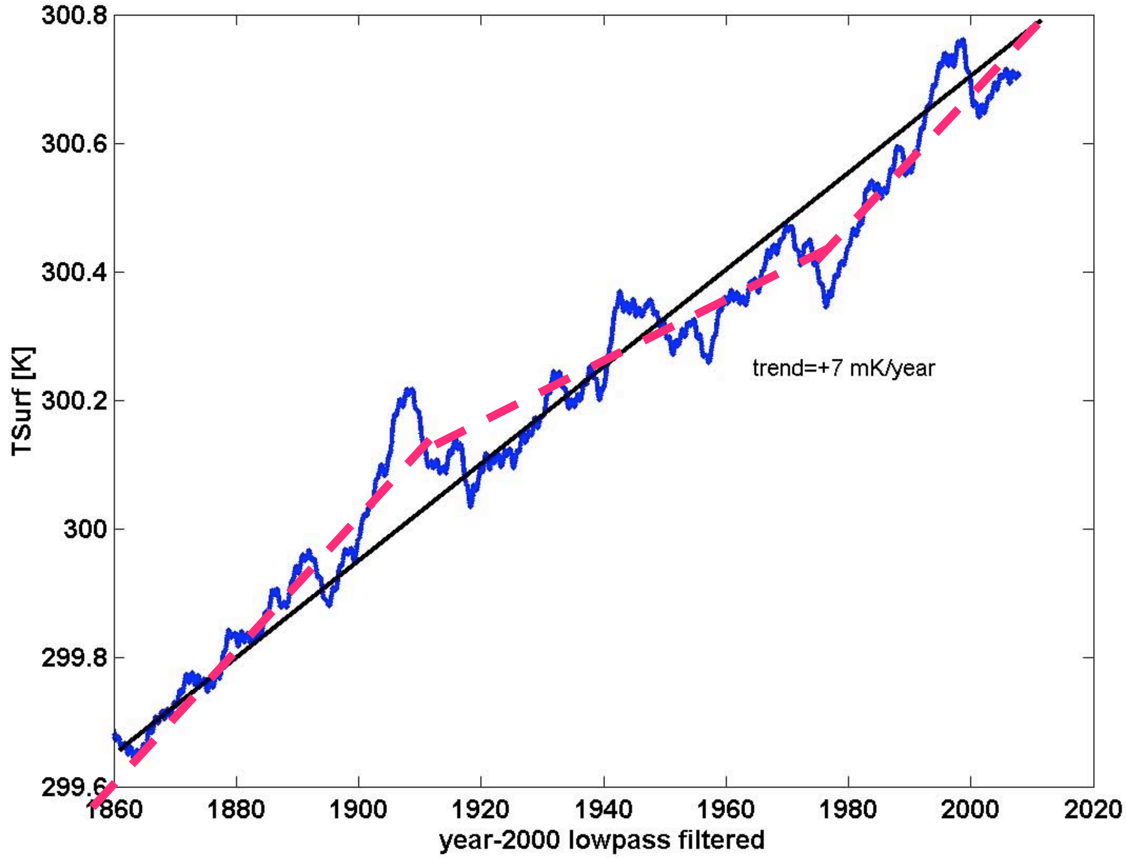
DCC are identified in the AIRS data as every footprints over non-frozen land or ocean where the 1231 cm-1 window channel brightness temperature is 210 K or less.
The DCC selected with this definition represent extreme convection.

In the tropical oceans this definition corresponds to cloud tops higher than 150 mb, i.e. penetrating through the tropopause.

Typically 10,000 DCC are identified globally each day, almost all within +/-30 degree latitude. About 7000 per day are in the tropical oceans (+/- 30 degree latitude).

Expected changes with global warming
+0.13 K/decade based on IPCC (2007)

Tropical Western Pacific



H. H. Aumann

Expected changes with global warming

The Clausius Clapeiron relationship shows that water vapor in boundary layer for 100% rel.humidity increases as +7%/K.

Prediction:
The multidecadal trend in the temperature is 0.13 K/decade, i.e. 7%/K * 0.13 K/decade = +1%/decade increase in water vapor.

From the 19 year reanalysis of SSMI data Wentz et al. (2007) claim +1.5%/decade for low rate precipitation.

20 years of HIRS data (Wylie et al. 2005) show no significant increase in the low fraction and high cloud (400 mb) fractions.

If we can characterize DCC as a process which occurs with a frequency which is a function of the mean zonal surface temperature, we can use the established multi-decadal trend of global warming to predict the multi-decadal trend in DCC frequency.

We analyze the data in terms of the DCC frequency, i.e. the count divided by the number available spectra.

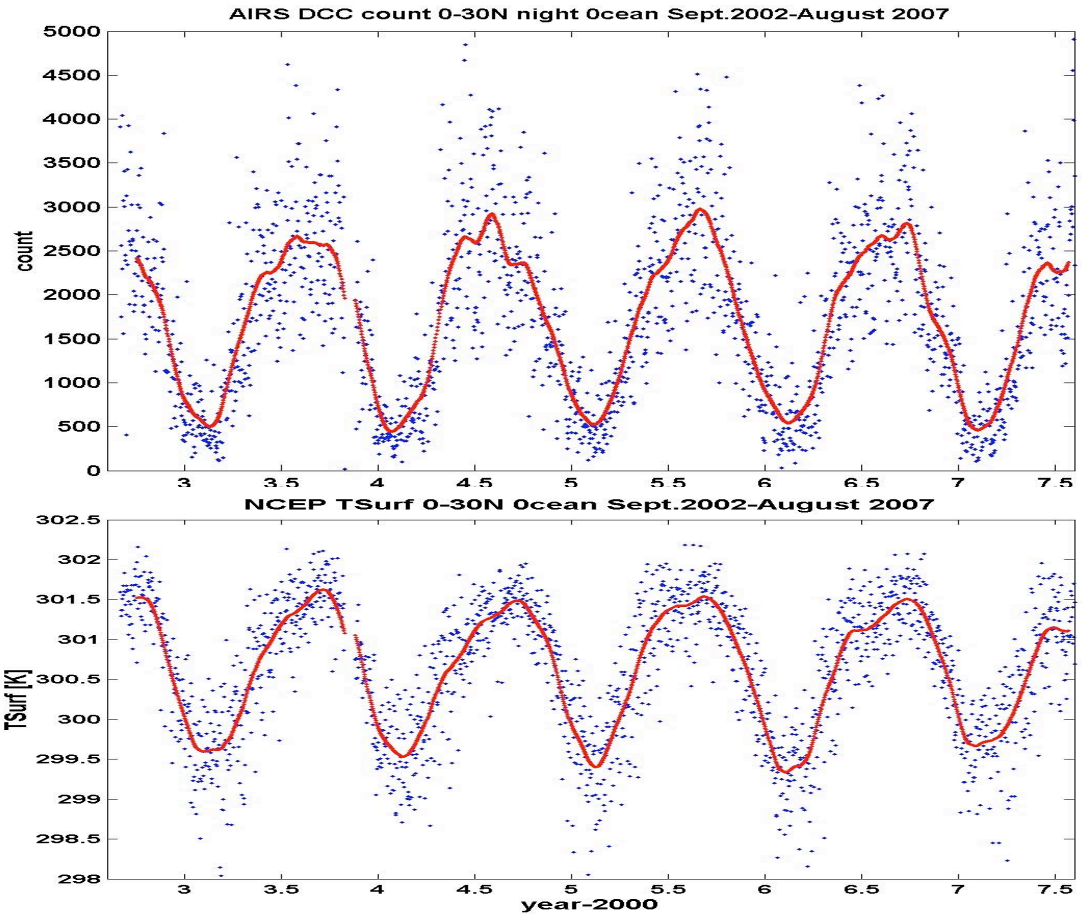
The DCC frequency for the tropical oceans is approximately 1%, almost day/night independent for the 1:30 pm EOS Aqua orbit.

The IASI DCC frequency (9:30 am orbit) is consistent with AIRS

DCC count is highly correlated with the mean zonal SST

DCC count

Zonal mean TSurf

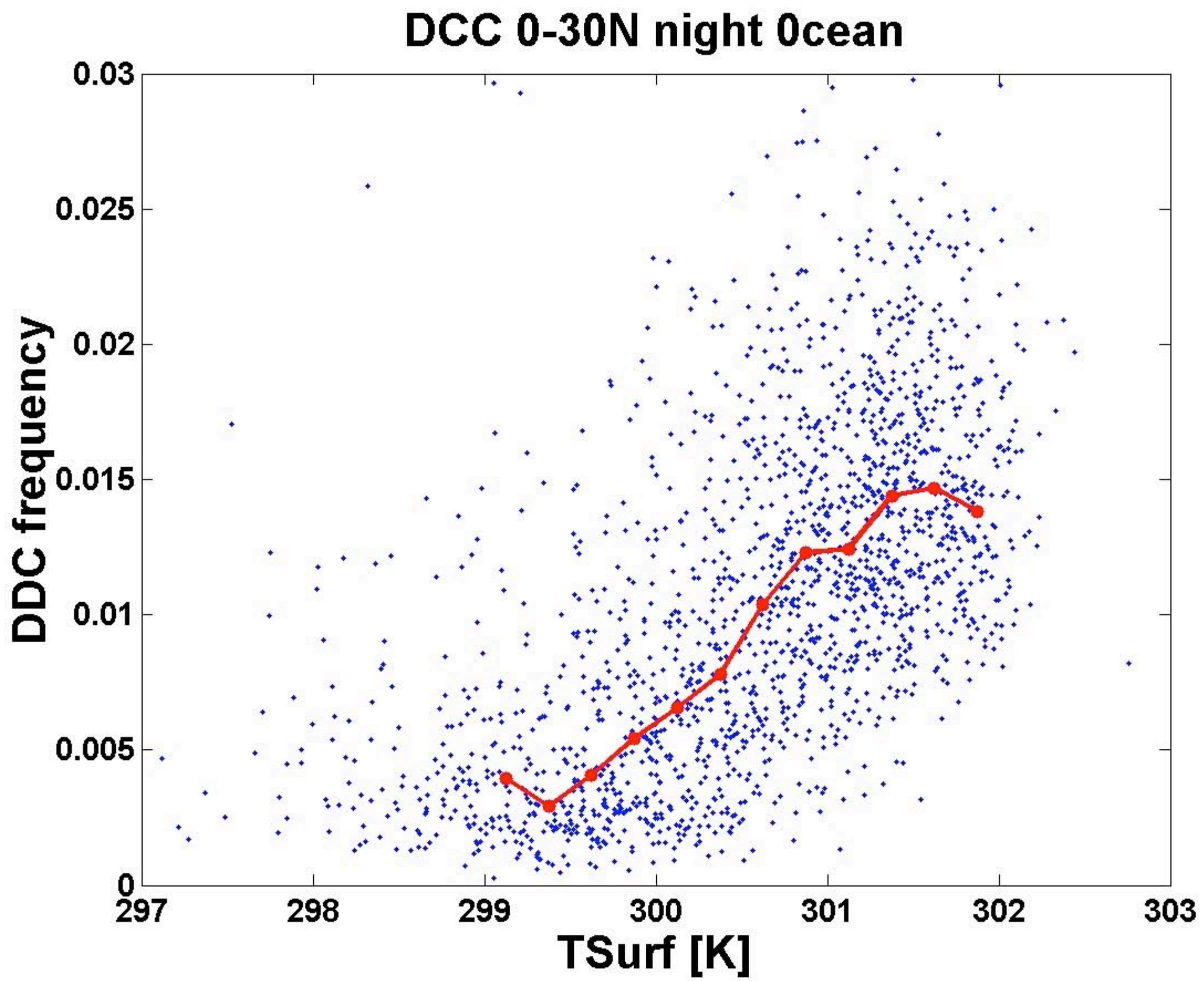


For night 0-30N the correlation is 0.62

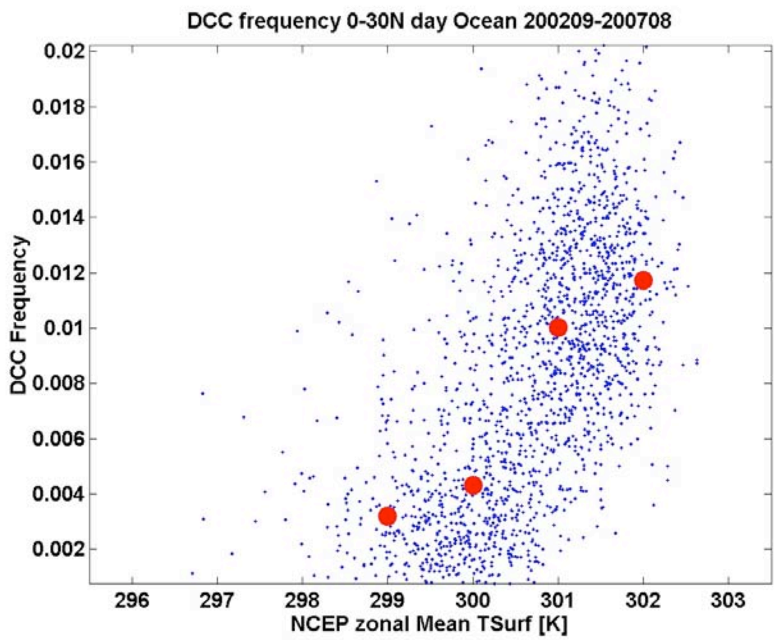
Aumann et al. 2007 GRL

H. H. Aumann

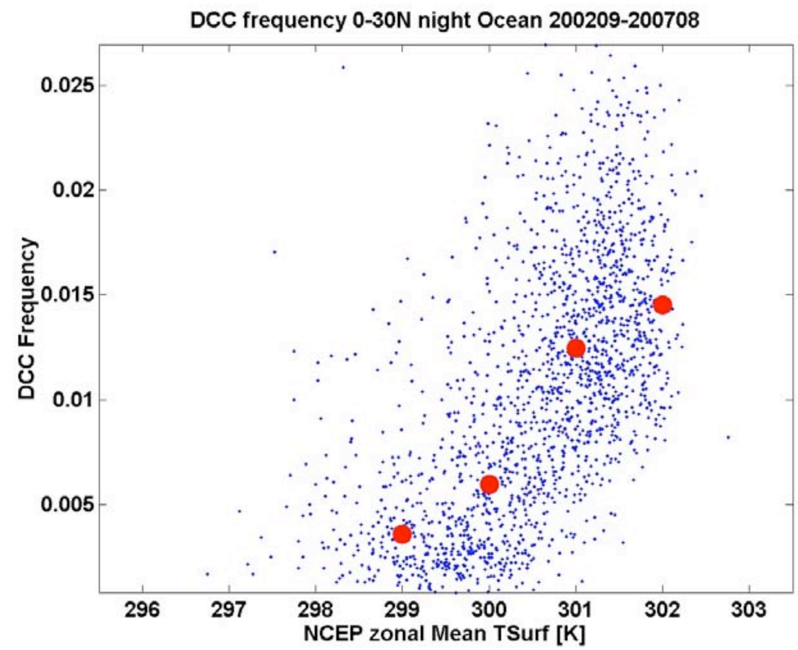
DCC frequency correlation with TSurf results in a DCC frequency sensitivity with units of %/K



We evaluate the sensitivity near 300 K



Ascending orbits



Descending orbits

The tropical ocean mean DCC frequency sensitivity is (+61±21) %/K

V1.1	Five year mean DCC frequency	DCC frequency/ TSurf correlation	sensitivity [fraction/K] with TWP
0-30N day	0.0085	0.611	0.720
night	0.0105	0.622	0.830
0-30S day	0.0062	0.661	0.335
night	0.0073	0.678	0.576

The same tropical ocean mean sensitivity can be deduced with and without the TWP

With the TWP / Without the TWP

V1.1	Five year mean DCC frequency	DCC frequency/ TSurf correlation	sensitivity [fraction/K] with TWP		Five year mean DCC frequency	DCC frequency/ TSurf correlation	sensitivity [fraction/K] without TWP
0-30N day	0.0085	0.611	0.720		0.0058	0.603	1.129
night	0.0105	0.622	0.830		0.0066	0.610	1.110
0-30S day	0.0062	0.661	0.335		0.0027	0.591	0.327
night	0.0073	0.678	0.576		0.0035	0.592	0.269

Expected changes with global warming

The Clausius Clapeiron relationship predicts +7%/K for water vapor in boundary for 100% rel.humidity.

The multidecadal trend in the temperature is 0.13 K/decade, i.e. 7%/K * 0.13 K/decade = +1%/decade increase in water vapor.

The mean DCC frequency sensitivity is (+61±21) %/K

Global warming is (+0.13±?) K/decade

predicted increase in DCC frequency
(+61±21) %/K * 0.13K/decade = (+8±2.5) %/decade

This rate is 8 times faster than the increase in water vapor predicted by applying the Clausius Clapeiron relationship.

The mean DCC frequency sensitivity is (+61±21) %/K

Global warming is (+0.13±?) K/decade

predicted increase in DCC frequency
(+61±21) %/K * 0.13K/decade = (+8±2.5) %/decade

This rate is 8 times faster than the increase in water vapor predicted by applying the Clausius Clapeiron relationship.

Is this increase consistent with anything else?

Rosenlof et.al (2001, Climate) shows that stratospheric water vapor has increased by 10%/decade over the past 50 years.

W. G. Read et al. (2004, JGR) point to deep convective clouds.

The 8%/decade increase in the DCC frequency provide a mechanism for an increased break in the tropopause and water vapor injection into the lower stratosphere.

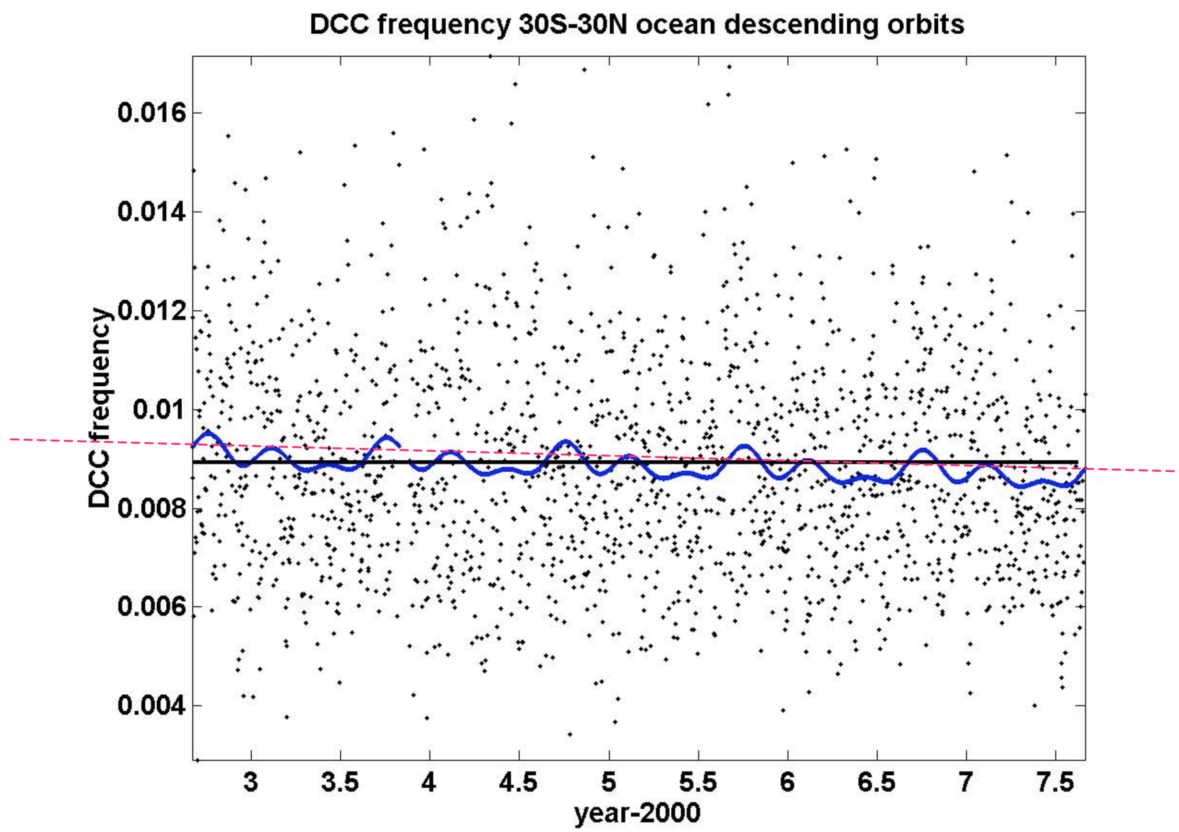
Rosenlof et.al (2001, Climate) shows that stratospheric water vapor has increased by 10%/decade over the past 50 years.

W. G. Read et al. (2004, JGR) point to deep convective clouds.

The 8%/decade increase in the DCC frequency provide a mechanism for an increased break in the tropopause and water vapor injection into the lower stratosphere.

Do we see a trend in the DCC frequency in the first five years of AIRS data?

The 5 year (2002-2007) trend in the day+night tropical ocean DCC frequency anomaly shows a small decrease!



Each dot is the count of one day

The blue traces is a 32 point smoothing filter

H. H. Aumann

The 5 year trend in the DCC frequency anomaly shows a marginally significant decrease

30S-30N	Five year mean	Anomaly trend	one sigma trend uncertainty
DCC freq. day	0.0072 frequency	-0.20 %/yr	0.52 %/yr
DCC freq. night	0.0086 frequency	-0.96 %/yr	0.51 %/yr

Observed trend is (-0.6±0.4)%/year

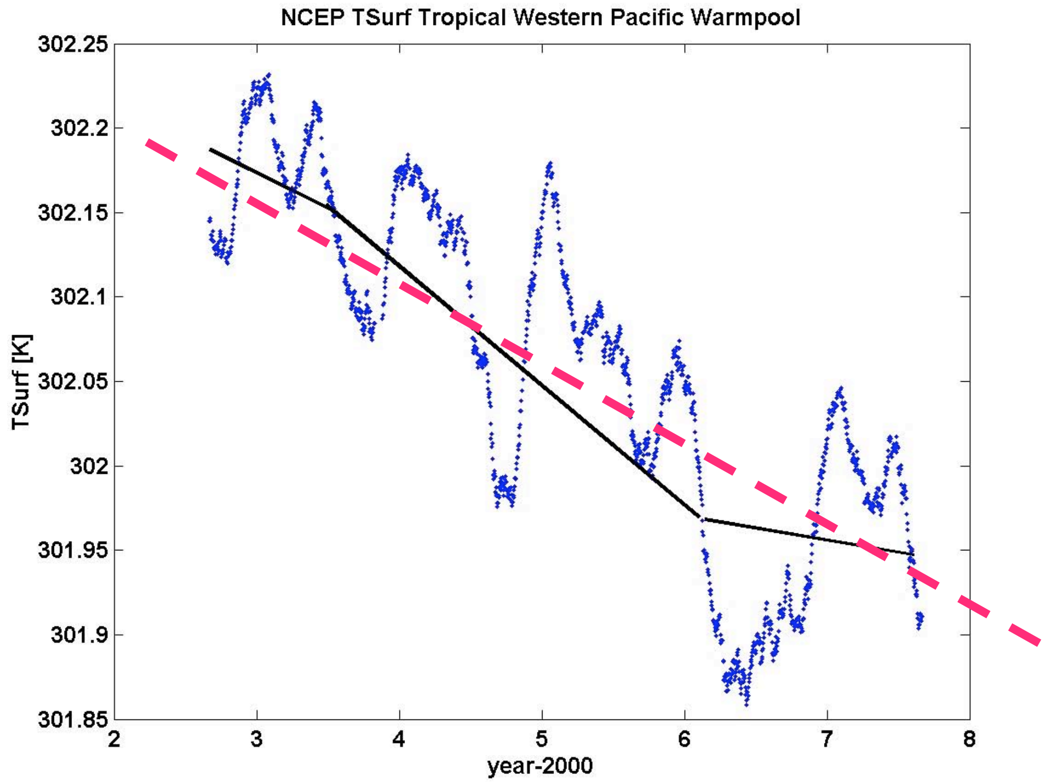
The measured DCC frequency trend is three times larger than the upper limit on the trend based on radiometric stability

The DCC are selected by a temperature threshold of 210K.
A trend in the radiometric stability produces a spurious trend in the DCC frequency.

The DCC frequency increases 20%/K for a shift in the selection threshold from 209K to 210K.

The AIRS radiometric stability is better than 10 mK/year.
The spurious trend in the DCC frequency due to a radiometric trend is less than 20%/K * 0.01K/year = 0.2%/year

The NCEP SST for all tropical oceans between 2002 and 2007 shows a small but significant trend of -23±8 mK/yr



The decrease in the TWP was -40 mK/yr

H. H. Aumann

The NCEP SST for the tropical oceans between 2002 and 2007 shows a small but significant trend of -23±8 mK/yr

This is consistent with Camp and Tung (2007) who claim that going from the maximum solar cycle in 2002 to the minimum in 2007 will produce a -20 mK/yr effect

The DCC frequency based on the -23±8 mK/yr SST trend
and (+61±21) %/K DCC frequency temperature sensitivity
Predicted (-1.4 ±0.5)%/yr
Observed (-0.6 ± 0.4) %/yr

Student t=0.8/0.64 = 1.2. 20% confidence.

The predicted trend is marginally consistent with the observed trend.
The expected 12 years of AIRS data should improve this.

Conclusions

We predict the frequency of Deep Convective Cloud to increases much faster than the 1.5%/decade measured for precipitation. The correation between DCC and severe storms,

The prediction may explain the observed increase in stratospheric water vapor over the past 50 years.

AIRS measurements of the change in the frequency of DCC between 2002 and 2005 show a decreased frequency marginally consistent with the cuurently observed cooling of the tropical oceans.